Section V: Whole Building M&V—Option C

This section of the Guidelines provides information on how to measure and verify savings using Option C—whole building analysis. Chapter 21 introduces Option C and describes general M&V issues related to the approach. Chapters 22 and 23 describe method-specific approaches for general variable-load retrofits using utility bill regression and utility bill comparison, respectively.

Chapter	Method Description	Method Number
22	Utility bill analysis using regression model	GVL-C-01
23	Utility bill comparison (with a discussion of energy accounting)	GVL-C-02

21

Introduction to Option C

Option C encompasses whole-facility or main-meter verification procedures that provide retrofit performance verification for those projects in which whole-facility baseline and post-installation data are available. Option C usually involves collecting historical whole-facility baseline energy use data and the continuous measuring of whole-facility energy use after ECM installation. Baseline and periodic inspections of the equipment are also warranted. Energy savings under Option C are estimated by developing statistically representative models of whole-facility energy consumption (i.e., therms and/or kWh) or performing simple utility bill comparisons.

In general, Option C should be used with complex equipment replacement and controls projects for which predicted savings are relatively large (i.e., greater than about 10% to 20% of the site's energy use), on a monthly basis. Option C regression methods are valuable for measuring interactions between energy systems or determining the impact of projects that cannot be measured directly, such as insulation or other building envelope measures. Specific difficulties associated with Option C methods include meeting the following requirements:

1. Using at least 12, and preferably 24, months of pre-installation data to calculate a baseline model
2. Using at least 9, and preferably 12, months of post-installation data to calculate first-year savings
3. Collecting adequate data in order to generate accurate baseline and post-installation models, and, if required
4. Adjusting the analyses to have the baseline meet minimum operating conditions or energy standards (e.g., minimum ventilation rates that exceed current conditions).

21.1 Approach

With Option C, energy savings evaluations using whole-building or facility-level metered data may be completed using techniques ranging from simple billing comparison to multivariate regression analysis. Utility bill comparison is the use of utility billing data (therms, fuel oil, kW, kWh) and simple mathematical techniques to calculate annual energy savings. Utility bill comparison is a very simple and, typically, an unreliable method. It is applicable only to very simple ECMs in which energy use changes are a direct result of ECM installation. Therefore, this method is not recommended for most federal ESPC projects.

Option C regression modeling is a specific statistical technique appropriate for determining energy savings under a performance contract. Regression models can take into account the impacts of weather and other independent variables on energy use; utility bill comparison techniques can not.

Utility bill regression analysis involves developing a model to estimate baseline energy use. Energy savings are estimated by comparing energy use predicted by the baseline model (forecasted into the post-installation period) to post-installation utility billing data. The analysis requires an empirical evaluation of the behavior of the facility as it relates to one or more independent variables. The variables may include weather, occupancy, and production rate.

In general, the procedure for determining energy savings with a regression model is as follows:

1. Develop the appropriate baseline model for the baseline period that represents normal operations.
2. Project the baseline energy use into the post-installation period by driving the baseline model with the post-installation weather and independent variable values.
3. Calculate savings by comparing the difference between predicted baseline energy use and the actual energy use of the post-installation period.

The best regression model is one that is simple and yet produces accurate and repeatable savings estimates. Finding the best model often requires the testing of several to find one that is easy enough to use and that meets statistical requirements for accuracy.

21.2 M&V Considerations

The following points should be considered when conducting Option C analyses for M&V:

1. All explanatory variables that affect energy consumption as well as possible interactive terms (i.e., combination of variables) must be specified, whether or not they are accounted for in the model. Critical variables can include weather, occupancy patterns, set points, and operating schedules.
2. Independent variable data will need to correspond to the time periods of the billing meter reading dates and intervals.
3. If the energy savings model incorporates weather data, the following issues should be considered.

- If the energy savings model incorporates weather data, the following issues should be considered: Use of the building “temperature balance point” for defining degree-days versus an arbitrary temperature base.

- The relationship between temperature and energy use that tends to vary depending upon the time of year. For example, an ambient temperature of 55°F in January has a different implication for energy usage than the same temperature in August. Thus, seasons should be addressed in the model.

- The nonlinear response to weather. For example, a 10°F change in temperature results in a very different energy use impact if that change is from 75°F to 85°F rather than 35°F to 45°F.

- Matching degree-day data with billing start and end dates.

4. The criteria used for identifying and eliminating outliers must be documented. Outliers are data beyond the expected range of values (or two to three standard deviations away from the average of the data). Outliers should be defined using common sense as well as common statistical practice.
5. Statistical validity of the final regression model must be demonstrated. Validation steps include checks to make sure that:
   - The model makes intuitive sense; that is, the explanatory variables are reasonable and the coefficients have the expected sign (positive or negative) and are within an expected range (magnitude).
   - Modeled data are representative of the population.
   - Model form conforms to standard statistical practice.
   - The number of coefficients is appropriate for the number of observations (approximately no more than one explanatory variable for every five data observations).
   - All model data are thoroughly documented, and model limits (range of independent variables for which the model is valid) are specified.

21.3 Data Collection

Collecting data, validating the data, and ensuring that all start and end dates of the data are aligned are important elements of billing analysis. Data types and some data analysis protocols are discussed below.

21.3.1 Data Types

Billing data provide the basis for calibrating models and post-installation energy use.

Other site data provide a means for controlling changes in energy use not associated with ECM installation. These data elements are discussed below.

Monthly billing data. There are typically two types of monthly billing data: total usage for the month and usage aggregated by time-of-use periods. Although either type of data can be used with a regression model, time-of-use is preferable because it provides more insight into usage patterns. In many cases, the peak demand is also recorded.

Interval demand billing data. This type of billing data records the average demand (or energy use) for a given interval (e.g., 15 minutes) associated with the billing period.

Stored energy sources. Inventory readings or delivery information can be used to determine historical consumption for resources such as fuel oil.

Site data. Site data provide the information necessary to account for changes in energy consumption that are not associated with the retrofit equipment. Typical site data that can be incorporated in regression models include weather parameters, occupancy, facility square footage, and operating hours. These data are typically used to help define the independent variables that explain energy consumption or changes associated with equipment other than the installed equipment.

22

Utility Billing Analysis Using Regression Models

This Option C approach uses regression models and utility billing data (therms, fuel oil and/or kWh, and kW) to calculate annual energy savings. In general, Option C should be used with complex equipment replacement and controls projects for which predicted savings are relatively large—i.e., greater than 10% to 20% of the site's energy use, on a monthly basis.

Unlike the Option C approach in which billing comparison methods are used (described in Chapter 23), regression analyses can take into account many independent variables and thus provides a more reliable estimate of energy savings.

22.1 Project Definition

Utility billing analysis using regression models is applicable for measurement and verification when the impacts of the ECMs are too complex to analyze cost effectively with Option B and when the rigor of Option D is not required.

Billing analysis is appropriate when:

- Savings are above noise—that is, the estimated energy savings are greater than at least 10% to 20% of the monthly utility bill being analyzed.
- There is a high degree of interaction between multiple measures at a single site.
- The ECM improves or replaces the building energy management or control system.
- The ECM involves improvements to the building shell or other measures that primarily affect the building load (e.g., thermal insulation, low-e windows).
- The measurement of individual component savings is not relevant.
- Other approaches are too expensive.

Regression analysis is a time-consuming task that requires experienced, qualified analysts. Specific difficulties associated with Option C methods include the following requirements:

- Using at least 12, and preferably 24, months of pre-installation data to calculate a baseline model
- Using at least 9, and preferably 12, months of post-installation data to calculate first-year savings
- Collecting adequate data in order to generate accurate baseline and post-installation models
- If required, adjusting the analyses so as to have the baseline meet minimum operating conditions or energy standards (e.g., minimum ventilation rates that exceed current conditions).

22.2 Overview of Method

Utility billing regression analysis is a highly specialized discipline. Contractors who plan to use this option should use this chapter for guidance and request that the federal agency review specific Option C issues. See sections 21.2 and 22.5 before preparing a project-specific M&V plan.

The M&V method described here is based in part on materials in the 1998 IPMVP. Information on the IPMVP can be found on the Web at www.ipmvp.org. Valuable insights into utility bill analysis can be found in the IPMVP.

Energy consumption under Option GVL-C-01 is calculated by developing statistically representative models of whole-facility energy consumption (i.e., therms and/or kWh). The types of models depend on the number of independent variables that affect energy use and the complexity of the relationships. The types of models that may be used include the following:

- One-parameter
- Two-parameter
- Change-point
- Multivariate.

The best model is one that is simple and yet produces accurate and repeatable savings estimates. Finding the best model often requires the testing of several to find one that is easy enough to use and meets statistical requirements for accuracy. This chapter discusses generic modeling issues, with an emphasis on multivariate modeling.

There are three approaches to calculating savings:

1. A baseline model is defined using regression analysis. The independent variables are input and estimated energy consumption is output. The model results are compared against actual post-installation meter readings to determine savings.

2. Separate models may be proposed that define pre-installation energy use and post-installation energy use with savings equal to the difference between the two.
3. A single "savings" model is generated that includes both baseline and post-installation factors. This approach is usually simpler and generates more reliable estimates, since it is also based on more data points than the second approach described here.

22.3 Data Analysis Protocols

This part describes some of the required data analysis protocols.

Baseline Energy Consumption. The regression analysis requires information that spans the full range of normal values for the independent variables. For weather-dependent ECMs, this usually means collecting data for at least one full heating and/or cooling season. The rule of thumb is that at least 12 months of data, before the date of the ECM installation, is required; however, at least 24 months of data are desirable, particularly if energy consumption is very sensitive to weather or other highly variable factors. If data are missing, the period of data collection should be extended; creating extra utility billing data points is generally not acceptable.

First-Year Post-Installation Energy Consumption. The regression analysis requires at least 9 months of data collected after the date of installation to determine impacts for the first year, and preferably 12 months of data before submitting the first-year M&V savings report.

Second-Year and Subsequent Year Post-Installation Energy Consumption. The billing analysis models should be updated until at least 18 months of post-installation data (but preferably 24 months) have been used to determine the independent-variable coefficients. The regression model coefficients can be either fixed during the term of the contract or continuously updated.

Outliers. The criteria used to identify and eliminate outliers needs to be documented in the project-specific M&V plan. Outliers are data beyond the expected range of values (e.g., a data point more than two standard deviations away from the average of the data). The elimination of outliers, however, must be explained; it is not sufficient to eliminate a data point simply because it is beyond the expected range of values. If data are found to be abnormal because of specific mitigating factors, then the data point can be eliminated from the analysis. If a reason for the unexpected data cannot be found, the data should be included in the analysis. Outliers will be defined according to "common sense" as well as common statistical practice. Outliers can be defined in terms of consumption changes and actual consumption levels.

22.4 Multivariate Regression Method

Multivariate regression is an effective technique that controls non-retrofit-related factors that affect energy consumption. If the necessary data (on all relevant explanatory variables, such as weather, occupancy, and operating schedules) are available and/or collected, the technique will result in more accurate and reliable savings estimates than a simple comparison of pre-and post-installation consumption loads.

The use of the multivariate regression approach is dependent on, and limited by, the availability of data. The decision to use a regression analysis technique must be based on the availability of appropriate information. Thus, on a project-specific basis, it is critical to investigate the systems that affect and are affected by the project and select all independent variables that have direct relationships to energy use. Data need to be collected for the dependent and explanatory variables in a suitable format over a significant period of time. For example, collecting chiller energy use over a wide range of ambient temperatures and indoor temperatures may require several months of data collection.

22.4.1 Overview of the Regression Approach

A regression model (or models) should be developed that describes changes between pre-installation and post-installation energy use for the affected site (or sites), taking into account all explanatory variables. For affected utility electric billing meters with time-of-use data, the regression model(s) will yield savings by the hour or critical time-of-use period. For meters with only monthly consumption data, the models will be used to predict monthly savings.

22.4.2 Standard Equation for Regression Analysis

In the regression analysis, utility meter billing data (monthly or hourly) on a project-specific basis is used to prepare models for comparing energy use before the installation of ECMs to energy use after they are installed. Any differences, after adjusting for non-retrofit-related factors, are then defined as the gross load impacts of the project at the site.

The regression equations should be specified so as to yield as much information as possible about savings impacts. For example, with hourly data, it should be possible to estimate savings impacts by time of day, day of week, month, and year. Using only monthly data, however, it is possible to determine effects only by month or year. Data with a frequency lower than monthly should not be used under any circumstances.

The standard form of a multivariate regression model, for a weather-dependent ECM, is:

$$Q_i = B_1 + (B_2 \times (T_i - T_{i-1})) + (B_3 \times HDD_i) + (B_4 \times CDD_i) + (B_5 \times X_1) + (B_6 \times X_2) + (B_7 \times X_3)$$

where:

Q = energy use

i = index for units of time per meter data point

B_n = coefficients

T = ambient temperature

HDD = heating degree days

CDD = cooling degree days

X_n = independent steady-state variables.

22.4.3 Explanatory Variables

A list of explanatory variables that affect energy consumption as well as interactive terms (i.e., combination of variables) needs to be specified. Critical variables can include weather, occupancy patterns, and operating schedules. The most common variable is outdoor temperature for many types of ECMs. Other examples of variables are building occupancy, number of meals served, and time of day.

Model Limits

Models are generally valid only for the range of independent variables that are used to determine the regression model. For example, if a regression model was "tuned" using ambient temperature data between 30° and 75°F, the model is documented to be valid only for that range—i.e., the model limits are 30° and 75°F. If a situation arises in which energy use or savings must be calculated when the ambient temperature is 80°F, the model may or may not be valid. Model limits should always be specified in conjunction with a definition of the regression model(s).

Independent Variable Ranges

It is important that the data collected on each independent variable span as large a range as possible. For example, if building occupancy during the 24 months before a retrofit varied only between 65% and 75%, the model coefficient for occupancy will not be very meaningful. Not until occupancy varies significantly from 65% or 75% will it become apparent that the model cannot account for such a variation in occupancy, and this could take a long time. As a rule of thumb, a prospective independent variable should span a range of at least 2 to 1 (i.e., its highest value should be at least twice the lowest value for the related coefficient to be reliable).

Weather Data

If the energy-savings model incorporates weather in the form of heating degree days and cooling degree days, the following issues should be considered:

- Use of the building temperature balance point in defining degree days rather than an arbitrary degree-day temperature base
- The relationship between temperature and energy use that tends to vary depending upon the time of year. For example, a temperature of 55°F in January has a

different implication for energy usage than the same temperature in August. Thus, seasonality should be addressed in the model.

Relationships Between Variables

Independent variables must be truly independent of each other in order for regression models to be most accurate. Lack of independence is referred to as auto-collinearity. Adding variables that are not independent can result in no new information in the model and unstable results, if the standard statistical T-test (see below) does not indicate a problem.

22.4.4 Testing Statistical Validity of Model(s)

To be statistically valid, the final regression model will need to demonstrate that:

- The model makes intuitive sense—e.g., the explanatory variables are reasonable, the coefficients have the expected sign (positive or negative), and they are within an expected range (magnitude).
- The modeled data are representative of the population—i.e., the model limits (range of independent variables for which the model is valid) are reasonable.
- The form of the model conforms to standard statistical practice.
- The number of coefficients are appropriate for the number of observations (approximately no more than one explanatory variable for every five data observations).
- The T-statistic for all key parameters in the model is at least 2 (95% confidence that the coefficient is not zero).
- The model is tested for possible statistical problems (e.g., auto-collinearity), and if they are found, appropriate statistical techniques are used to correct for them.
- All data input to the model are thoroughly documented, and model limits are specified.

22.5 Calculating Savings

The details of the savings calculations are dependent on these kinds of issues:

- The use of hourly versus monthly utility meter billing data
- The format of the data (e.g., corresponding to the same time interval as the billing data) and availability of all relevant data for explanatory variables
- The amount of available energy consumption data
- Whether actual or typical data are used to calculate savings
- How energy standards are accounted for in the baseline.

Energy savings calculations may need to incorporate minimum operating standards, such as minimum ventilation rates or lighting levels. These standards may exceed actual baseline operating conditions; thus, modifications to the model(s) may be required.

Under some performance contracting arrangements, energy savings might need to be calculated by ECM when differential pricing is used. The method(s) for separating out energy savings by measure category (HVAC, lighting, and other) must be (a) specified in the project-specific M&V plan for the federal agency's approval and (b) done with Option D, calibrated simulation and/or Option B, end-use metering based analyses.

22.6 Project-Specific M&V Issues

When Option GVL-C-01 billing analysis methods are used, the project-specific M&V plan must address the following in addition to other topics generic to all M&V methods:

- The model type and format that will be used to define baseline and, possibly, post-installation energy use, as well as energy savings
- The explanatory (independent) variables that will be evaluated for inclusion in the model(s) and the expected limits for these variables
- The source and time frame of data that will be used to determine model coefficients
- The statistical tests that will be used to test the validity of the models
- The baseline modifications that the model(s) will capture and the frequency in which the model(s) will be updated
- How outlier data will be identified dealt with.

23

Utility Bill Comparison with a Discussion of Energy Accounting

Utility bill comparison is the use of utility billing data (therms, fuel oil, kW, kWh, etc.) and simple mathematical techniques to calculate annual energy savings. Utility bill comparison is a very simple and typically an unreliable M&V method. It is applicable only to very simple ECMs in which energy use changes are a direct result of ECM installation. Therefore, *this method is not recommended for most federal ESPC projects*.

Simple utility bill comparisons, however, and energy accounting tools can be used by facility operators to better understand and manage the energy consumption and loads in their facilities. This method also helps identify the effects of energy efficiency improvements.

Chapter 22 presents a specific statistical technique—utility bill regression analysis—which is an Option C method that can be used to determine energy savings under a performance contract. Utility bill regression models can take into account the impacts of weather and other independent variables on energy use while utility bill comparison techniques can not.

23.1 Project Definition

In general, utility billing analysis indicates the energy savings resulting from installing an ECM and all other variations (e.g., weather and change of use) that impact a facility's energy use.

Utility bill comparison is applicable when:

- Energy use does not change significantly as a result of independent variables such as weather, occupancy hours, or facility use. Such situations may be lighting retrofits of street or parking lot lighting or pumping system modifications for a constant-load irrigation system.
- A utility billing meter, or submeter, is connected to the facility or end-use subsystem (e.g., the parking lot lights or irrigation pumps) and at least one year (and preferably more) of historical data are available.
- The projected energy savings are at least 10% to 20% of the site's energy use, on a monthly basis.

23.2 Overview of Method

Energy savings can be derived from a comparison of post-installation energy consumption with that of the corresponding baseline period. This comparison uses utility billing data and can be done manually, on computerized spreadsheets, or with dedicated software.

A basic comparison approach is simple and easily applied when non-retrofit-related factors remain constant over the observation period. The approach requires a minimal amount of data collection since the information is available in utility meter billing data. Accounting for changes in energy consumption due to factors other than the energy efficiency improvement requires more sophisticated techniques.

A simple comparison approach is appropriate in evaluating energy savings when the value of a project is relatively low and the level of certainty in the estimates of savings is not critical. Projects in which payments are tied to performance associated with energy savings probably warrant conducting a more sophisticated analysis, such as regression, which is discussed in Chapter 22. Note that some energy accounting software includes regression features, but each has limitations associated with the number of parameters and types of regression equations allowed.

23.3 Comparison Methods

There are several ways to compare information from utility billing data. Three methods that vary in how they account for changes in one key factor (such as weather) are explained in the following parts of this chapter. In all of the methods, a correction must be made for the varying numbers of days in utility billing periods.

23.3.1 Present-to-Past Comparison

Present-to-past comparison is the simplest method of comparing energy use, requiring only monthly utility bill data. In this method, energy usage for a given period (a month, quarter, year, or other period) is compared with that of the same period of the previous year or a base year.

This method, however, does not account for changes in weather or any other factors. It works well for facilities that use electricity for lighting and small motors but not heating and cooling.

To obtain reasonable comparisons between time periods, it is necessary to prorate by month the amount of energy consumed in each billing period, since the number of days in billing periods can vary. To calculate savings, post-installation energy use is subtracted from a pre-installation energy use for the same calendar month.

23.3.2 Multiple-Year Monthly Average Comparison

Multiple-year comparison provides a more accurate reflection of historical heating and cooling usage than does the present-to-past comparison, especially if other factors, such as square footage and hours of equipment operation have remained constant.

In multiple-year, monthly-average utility-bill comparison, energy use from the same time period over a number of years is averaged to develop a baseline. For example, energy use in January 1996 could be compared with average energy use for January 1993, 1994, and 1995. This way, variations in weather are smoothed out to create a more realistic base.

The main drawback for this method is that it does not account for unusual temperatures during the current year. If winter is colder or summer is hotter than normal, savings might be underestimated. (In this method, as in the present-to-past comparison, an adjustment must be made if the number of days in the billing period varies.)

23.3.3 Temperature-Corrected Method—Heating Degree Days/Cooling Degree Days

The temperature-corrected comparison method provides some correction for variations in weather; however, it is not as accurate as the regression analysis methods, described in Chapter 22.

Temperature correction requires the collection of weather data as well as utility bill information and uses a statistical model to adjust the current year to the baseline. Heating and cooling degree days (HDD and CDD) are used to adjust energy consumption data before calculating energy savings. A normalization adjustment should be made only if there is a statistically significant correlation between HDD or CDD and energy consumption with a particular fuel.

If other non-retrofit-related factors change, they can also be controlled by normalizing consumption to typical or baseline conditions. Even with normalization, the saving estimates under these circumstances may be suspect without a full examination of all the effects of non-retrofit-related factors. In addition, a possible issue with normalizing is that the resulting change in energy consumption is based on typical or baseline conditions rather than actual conditions in the post-installation year. Another issue is that normalizations are not always linear. For example, a building's gas consumption for space heating would not vary with HDDs above or below a certain number of degree days. These types of problems can be dealt with more easily using a multivariate regression analysis.

Regression analysis, as discussed in Chapter 22, is a better method of modeling energy consumption, and calculating actual energy savings, when there are numerous factors beside the energy efficiency improvement affecting energy consumption.

23.4 Energy Accounting Software

The following discussion of energy accounting tools is based in part on a handbook from the California Energy Commission titled, “Energy Accounting: A Key Tool in

Managing Energy Costs," (May 1997, P400-97-001G). The handbook also includes tips on selecting software and a comparison chart of the five software packages listed here. More information can be obtained by calling (916) 654-4304 or by visiting the web site at www.energy.ca.gov.

Billing analysis that compares billing data and/or makes adjustments for changes in energy consumption due to non-ECM-related factors could be conducted through the use of energy accounting software. Energy accounting is a system used to record, analyze, and report energy consumption and cost on a regular basis. Commercially available software packages provide the structure for energy accounting and can enhance energy management.

Energy accounting software can be used to provide feedback on how much energy a facility uses and how much it costs. It also shows reductions due to energy efficiency savings, and it can provide a means to communicate energy data that facility staff, building occupants, and managers can use to monitor and improve energy management. Energy accounting software can help users do the following:

- Record and attribute energy consumption and costs
- Troubleshoot energy problems and billing errors
- Provide a basis for setting priorities among energy capital investments
- Evaluate energy program success and communication results
- Create incentives for energy management
- Budget more accurately
- Position an organization to shop for lower prices for energy in a changing electricity market.

23.4.1 Features of Available Software

Energy accounting software programs vary in their complexity, user friendliness, application, and cost. Selecting from different programs can be challenging. A good starting point is to examine the following basic features found in most software:

- Organization/site records
- Billing and climate records
- Output data, reports, and graphs
- Documentation and support.

Organization/Site Records

Each software program must be able to record basic site information, including the name of the site, its address, and associated accounts and meters. Site records should also record the square footage of each building, gallons of water for each pump, or other appropriate units of measure.

Some software programs may limit the number of sites or meters that can be tracked, or the software price may depend on the number of meters, so it is important to ensure that the software can accommodate the needs of the federal agency. Most energy accounting software uses a hierarchical organization structure for buildings, accounts, and meters. More levels, such as departments, areas within buildings, or submeters (if used), may also be useful for more detailed tracking. The ability to group sites into departments, for example, is useful if each department has its own energy budget.

Billing and Climate Records

All the reviewed commercial software programs record total monthly energy consumption and cost based on monthly utility bills for each fuel. All allow at least some additional detail, such as recording and breaking out of the cost of electrical demand, different charges for different times of use, and power factor charges from electricity bills.

The software needs to record monthly billing-period dates. This allows the program to prorate consumption and cost by calendar month. To make meaningful comparisons of current-to-past energy use, at least one year of historical data must be used for the baseline. With some software, the baseline may include more than one year's worth of historical energy-consumption data. Some programs may be limited as to how many years of data can be stored.

Different software programs vary as to what non-energy utilities can be tracked (i.e., water, sewer, garbage or recycling revenue). It may be worth the extra cost to purchase software that can track non-energy utilities if that data is useful to your organization.

Commercial software also requires entering HDD and CDD or other weather data—average monthly temperature or daily temperatures—to support adjustments to account for the effect of weather on energy consumption. Some software providers offer periodic installments of weather data for your weather station(s) for an additional cost. Weather data are also available from commercial and government sources or directly from your local weather stations.

Each program uses a different model for applying weather corrections to energy savings calculations. Explanations of the models are included in each program's user manual. Some software allows the user to adjust parameters such as the temperature at which cooling or heating use is required (balance temperature). This can result in greater accuracy in estimating savings, but requires sufficient technical expertise on the part of the user.

The ability to electronically import billing data provided by utilities can be a significant time saver. Some of the software providers will create additional software needed to import billing information provided in a specific format by your utility. Some energy accounting software also allows weather data to be imported electronically.

Energy consumption data may be electronically downloaded directly from facilities' meters. Some utilities may also offer this service directly to large customers.

Linking the software directly to meters is the best way to get precise demand-period (15-minute) energy use information. This amount of detail will be useful for shedding demand during peak periods or for considering the use of real-time pricing when purchasing electricity.

Output Data, Reports, and Graphs

Basic reporting needs include the following:

- Monthly and yearly energy usage and cost reports for each site. Often a single report will combine monthly and year-to-date totals.
- An executive summary of the organization as a whole. Ideally, this report should be no longer than a few pages and should show at a glance the performance of major departments and the entire organization, including dollar savings. Reports or graphs with this information are critical in providing administrators with easy-to-understand information on your energy management efforts.
- Monthly direct side-by-side comparisons of current energy use with the baseline or previous year's use for each site. This kind of report or graph allows the users to observe changes in energy use patterns that result from operational changes, equipment failures, retrofits, or other factors.
- A two-year comparison graph. This provides an easy way to track progress in reducing costs or spot problems at individual sites.
- Calculations of comparison parameters. These can include the percentage change in fuel use, dollar cost per square foot, total Btu per square foot, and actual fuel use in therms or kWh per square foot. These parameters make it easier to compare similar buildings. Depending on how the data are used, the most appropriate parameters may vary. Percent of change is useful because goals are often set in these terms. Cost information is more meaningful to most people than kWh and Btu.
- Graphs. Visual presentation of data is usually more effective in getting the point across. Many energy accounting software programs now have the capability of attractively formatted color graphs.

Most energy accounting suppliers will provide potential customers with a trial copy of the software. Reviews of software packages should include examining the data entry methods, checking standard reports and customizable features, and ensuring that the software meets federal needs for content and format.

Documentation and Support

At a minimum, the software documentation must explain each entry screen or window and menu of options. There should also be access to technical support.

23.4.2 Selected Software Packages

Some of the most commonly used energy accounting software includes:

- ENACT
- ENVISIONTM
- FASER
- METRIX
- The Utility Manager (UM).

Most of the main energy accounting programs are Microsoft® Windows®-based. There are a variety of procedures for using energy data, creating reports and graphs, and flagging possible errors.

Ideally, the basic functions should be simple, easy to use, and offer automatic feedback when questionable data are entered. If billing data will be imported electronically, the software must be able to accept different utility billing data formats.